



Builders Without Borders

Ecological designers and builders working towards a sustainable future
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Nepal Engineers' Association Design Competition of Rural Housing Report for Submittal of 1-1/2 Story Straw Bale House Design

Date: 26 December 2015

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A. Design Description, Context and Features:

Builders Without Borders' 1-1/2 story Straw Bale House

accommodates 3-6 people, and can be built in 4 phases. It consists of two rooms with dimensions of 4290 X 3530, a kitchen 2030 X 2300, a multi-purpose room 2030 X 2300, and a veranda 4670 X 2500. It features a **useable attic** for crop drying and storage. The **total floor area** including veranda but excluding attic is **65 m² (700 ft²)**.



Typical residence in Khorang

Context: The design is derived from the local architecture in the Khandbari vicinity in **Sankhuwasabha** district, by visiting earthquake damaged and undamaged houses and speaking with members of these households. This occurred in Khorang and Khandbari. Altitude in the locations studied varies from 500–1200 meters. Khandbari is the population center of an agricultural region that suffered moderate earthquake damage.



Attics are important for homes in agricultural regions. They are commonly used for crop drying and storage.

However, this design is relevant in many regions of Nepal, at altitudes 500 to 3000 meters wherever rice, wheat, barley, or rye are grown and bamboo is available. Similar social, climate, economic, material, and architectural contexts can be found in other earthquake-affected districts such as **Gorkha, Dhading, Nuwakot, Sindhupalchok and Ramechhap**.

Although 2-1/2 story houses are common in Sankhuwasabha as well as the other 5 named districts, it was learned that **many people prefer to live in 1 story or 1-1/2 story houses after the earthquake**, because 2-story houses or taller were observed to collapse more often.

Kitchens are typically attached to the home and are preferred to have a direct connection to the veranda, where food prep often occurs. Most families prefer for **toilets to be detached** from the home.

The design uses local materials of stone, bamboo, straw, wood, sand and clay-soil. **The straw bale walls are highly insulating**, and **keep the interior warm** in winter and cool in summer. Plastered straw bale walls are also highly resistant to fire as shown through ASTM testing.



Kitchen in Khorang

Building Components:

Foundation: stone masonry with mesh-reinforced cement plaster,

Walls: stacked straw bales (compressed straw blocks, see sheet 2) stiffened with thru-tied vertical bamboo, covered with mesh-reinforced clay or lime plaster, and with a wood top plate. Inexpensive nylon fishing net from Kathmandu or other population centers can be used for plaster mesh.

Attic Floor: bamboo truss chords and bamboo joists, split bamboo subfloor, light clay-straw floor

Roof: bamboo trusses and rafters, wood purlins, and CGI roofing

The earthquake-resistant design is based on a house design and construction method used by Pakistan Straw Bale and Appropriate Building (PAKSBAB) since 2007 which was **shake-table tested** at the University of Nevada, USA in 2009, and is consistent with the **2015 International Residential Code, Appendix S – Strawbale Construction**.

Architectural and material adjustments were made for the context of Nepal. Earthquake-resistant measures include **shock-absorbing straw bale walls** with through-tied **bamboo stiffeners** and **mesh-reinforced plaster**, a CGI

roof diaphragm, and well-connected components from roof to foundation. A seismic analysis and the roof framing design were done in accordance with the **Nepal National Building Code** and the **Indian Standard** for Structural



Shake-table test of Pakistan straw bale wall system in 2009 at the Univ. of Nevada, USA.

Design Using Bamboo.

Straw bale buildings have been constructed in all 50 U.S. states and over 50 countries worldwide, including every climate and high seismic regions. Some buildings from the early years of its invention in the U.S are over 100 years old.

B. Builders Without Borders – Organization and Nepal Team Background

Builders Without Borders (BWB) - www.builderswithoutborders.org

Builders Without Borders (BWB) is an international network of ecological designers and builders who advocate the use of straw, earth, bamboo and other local materials to construct safe, affordable, sustainable, and culturally appropriate shelter in places of need.

BWB designs prototypes or other projects with communities or other partners, and constructs pilot projects and conducts trainings to enable individuals, families and communities to provide their own sustainable shelter.

Since its inception in 1999, BWB has organized and supported its own projects and with partner

organizations in Mexico, Mongolia, China, Israel, South Africa, Siberia, Pakistan, Haiti and on Native American lands.

BWB Primary Team Members for Rebuilding in Nepal

Martin Hammer – Architect (California Lic. C17480), Co-director Builders Without Borders

Private practice in San Francisco, California area since 1986. Helped found Pakistan Strawbale and Appropriate Building in 2006-07 (paksbab.org) introducing seismic-resistant strawbale construction to earthquake-affected Pakistan. Worked in post-earthquake Haiti from 2010-2013 with the Earthquake Engineering Research Institute (eeri.org), the World Monuments Fund (wmf.org), and three years as project architect for BWB on prototype houses, and a school and community center for partner organizations. Lead author of Strawbale Construction appendix in the International Residential Code. Contributing author of *Design of Straw Bale Buildings*. Co-author of *Strawbale Building Tutorial for High Seismic Regions of the Developing World*.

(Note: NEC certificate not available. See California State architect's license below.)

Andy Mueller – Lead Builder, Designer

Principal of GreenSpace Collaborative, a natural design/build company in Massachusetts, USA. Lead builder for BWB in Haiti 2010-2012. Co-founder Natural Builders Northeast. Masters of Landscape Architecture, Univ. of Massachusetts. Green Planning study at Universitat, Hannover, Germany. Board member of Sheltering Pine Institute, a non-profit organization dedicated to building just and sustainable human ecosystems.

Kevin Donahue, SE and Anthony Dente, PE – Consulting Engineers

Principal and associate, KDSE (Kevin Donahue Structural Engineers) in Berkeley, California. Extensive experience with seismic design in high seismic California. Particular experience with structural design of strawbale buildings. Emphasis on design solutions achieving the greatest benefit with minimal construction costs. Contributing author of *Design of Straw Bale Buildings*.



